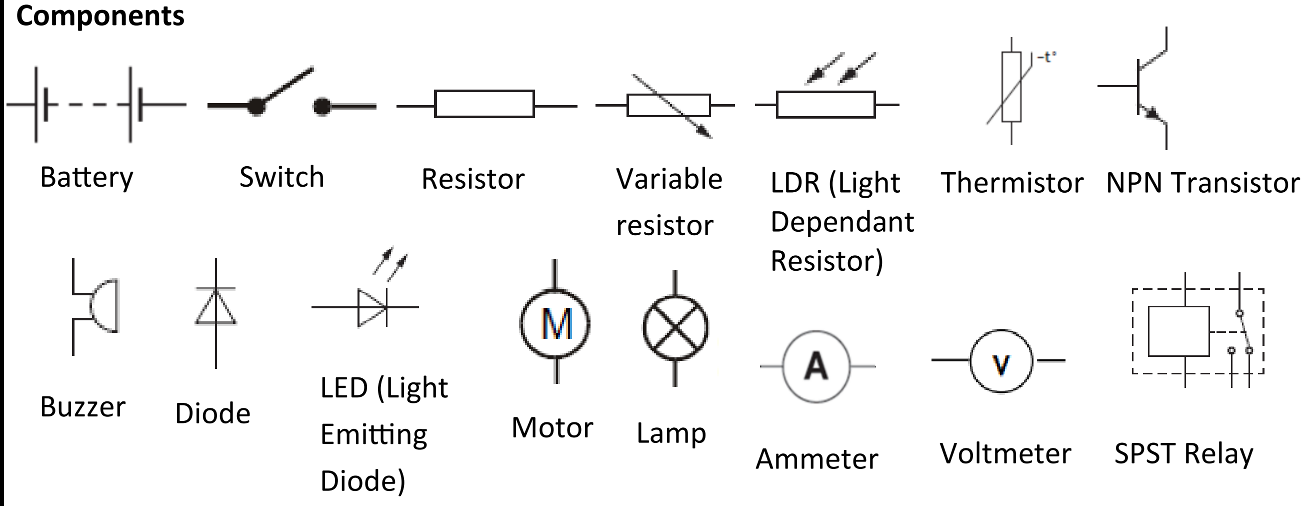
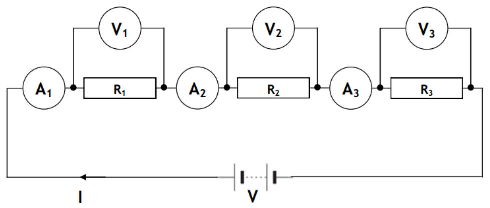
N5 Analogue Electronics

Components



Resistors in Series



$V = V_1 + V_2 + V_3$ (Voltage splits)

$I = I_1 = I_2 = I_3$ (Current stays the same)

$R_T = R_1 + R_2 + R_3$

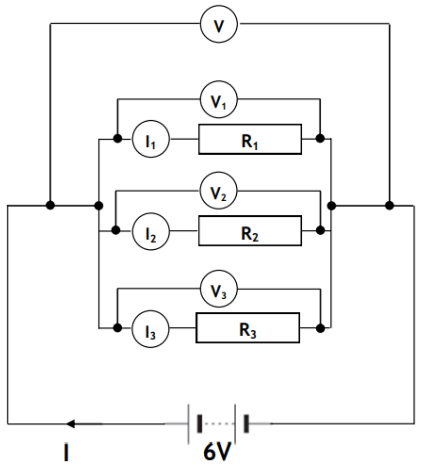
In a series circuit, if one component fails the circuit will be broken and current will not be able to flow.

The current is the same at any point in a series circuit.

The voltage across each component adds up to the supply voltage.

The total resistance in a series circuit is all of the resistances added together.

Resistors in Parallel



$V = V_1 = V_2 = V_3$ (Voltage stays the same)

$I = I_1 + I_2 + I_3$ (Current splits)

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

In a parallel circuit, if one component fails the current is still able to flow round the other branches which allows the other components to still function.

The current splits in a parallel circuit. I_T (total circuit current) is calculated using R_T (resistance total) and V_T (voltage total).

The voltage across each component stays the same in any part of the circuit. It is always equal to the supply voltage.

The total resistance in a series circuit can be calculated using either of two equations. The bottom one is easier for 2 resistances in parallel.

Ohm's Law

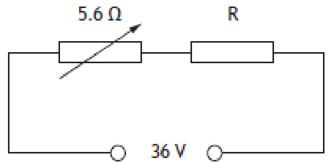
$$V = I \times R$$

Voltage (V) is measured in Volts (V).

Current (I) is measured in Amps (A).

Resistance (R) is measured in Ohms (Ω).

Ohm's law calculations



(a) Calculate the value to R to ensure that the circuit current is 2A.

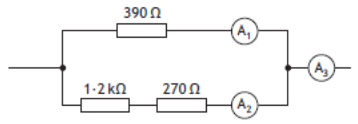
Step 1 - We know the total current and the total voltage so we can use Ohm's law to calculate the total resistance.

$$V_T = I_T \times R_T$$
$$36 = 2 \times R_T$$
$$\frac{36}{2} = R_T$$
$$R_T = 18\Omega$$

Step 2 - We can now work out what the resistance of R is as we know that the total resistance in a series circuit is just the resistances added together.

$$R_T = R_1 + R$$
$$18 = 5.6 + R$$
$$18 - 5.6 = R$$
$$R = 12.4\Omega$$

Combined resistance calculations



(a) Calculate the total resistance of this circuit.

First work out the total series resistance, then work out the parallel resistance using the total series value.

$$R_T = R_1 + R_2$$
$$R_T = 1200 + 270$$
$$R_T = 1470\Omega$$

$$R_P = \frac{R_1 \times R_T}{R_1 + R_T}$$
$$R_P = \frac{390 \times 1470}{390 + 1470}$$
$$R_P = \frac{573300}{1860}$$
$$R_P = 308\Omega$$

(b) (i) The reading on ammeter A_1 is 0.031A. Calculate the voltage across the 390Ω resistor.

Using Ohm's law to calculate the voltage.

$$V = I \times R$$
$$V = 0.031 \times 390$$
$$V = 12V$$

(b) (ii) Calculate the current A_2.

We know that voltage is the same in each branch of a parallel circuit, so Ohm's law again using 12V. Remember to add the resistances.

$$V = I \times R$$
$$12 = I \times 1470$$
$$\frac{12}{1470} = I$$
$$I = 8.2mA$$

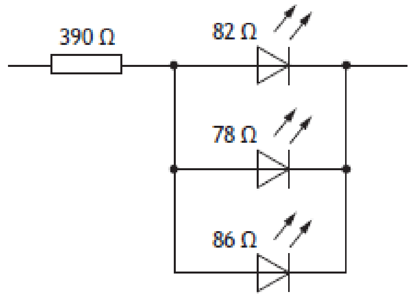
(b) (iii) Calculate the current A_3.

We know that the current splits in a parallel circuit so we need to add the current at A_1 and A_2 together to get the total current at A_3.

$$A_3 = A_1 + A_2$$
$$A_3 = 0.031 + (8.2 \times 10^{-3})$$
$$A_3 = 0.039A$$

Combined resistance calculations

Start these questions by solving the total resistance of the parallel branch. We then treat the parallel branch as a single resistance to calculate the total circuit resistance in series.



(a) Calculate the resistance of the 3 LEDs in parallel.

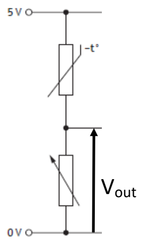
$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$
$$\frac{1}{R_P} = \frac{1}{82} + \frac{1}{78} + \frac{1}{86}$$
$$\frac{1}{R_P} = 0.03664$$
$$\frac{R_P}{1} = \frac{1}{0.03664}$$
$$R_P = 27\Omega$$

(b) Calculate the total resistance of the circuit.

$$R_T = R_1 + R_P$$
$$R_T = 390 + 27$$
$$R_T = 417\Omega$$

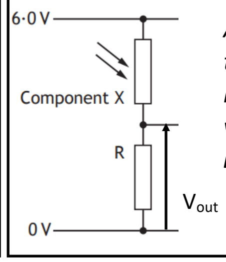
Voltage Dividers - Input sub-system

Thermistor at top = Heat sensor (TURD)



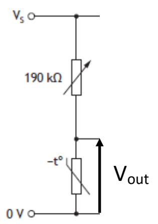
*As the temperature **increases**, the resistance of the thermistor **decreases**, causing the voltage across it to also **decrease**. This causes the share of the voltage across the variable resistor (V_{out}) to **increase**. The variable resistor acts as a sensitivity control.*

LDR at top = Light sensor (LURD)



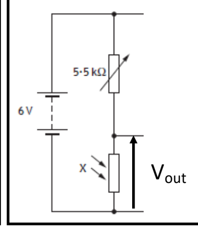
*As the light level **increases**, the resistance of the LDR **decreases**, causing the voltage across it to also **decrease**. This causes the share of the voltage across the fixed resistor (V_{out}) to **increase**.*

Thermistor at bottom = Cold sensor (TDRU)



*As the temperature **decreases**, the resistance of the thermistor **increases**, causing the voltage across it (V_{out}) to also **increase**. This causes the share of the voltage across the variable resistor to **decrease**. The variable resistor acts as a sensitivity control.*

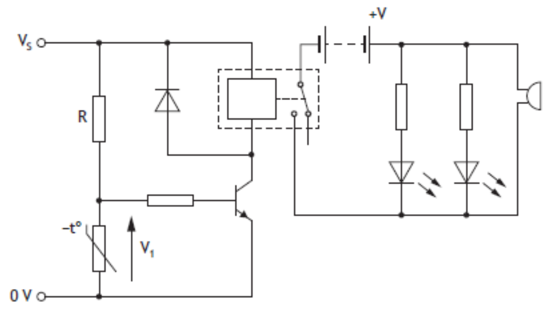
LDR at bottom = Dark sensor (LDRU)



*As the light level **decreases**, the resistance of the LDR **increases**, causing the voltage across it (V_{out}) to also **increase**. This causes the share of the voltage across the variable resistor to **decrease**. The variable resistor acts as a sensitivity control.*

Describing Circuits

(a) Describe the operation of the circuit. Make reference to the resistance of the thermistor and the voltage V_1.



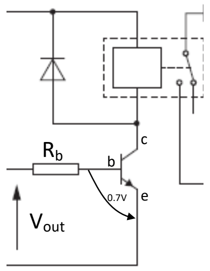
When the temperature decreases to a low temperature, the resistance of the thermistor will increase, causing V1 to increase. Once it increases above the threshold voltage, the transistor will saturate causing the relay to close the switch which will light the LEDs and sound the buzzer.

(b) The fixed resistor R is replaced with a variable resistor. Explain the effect on the operation of the circuit by replacing the fixed resistor (R) with the variable resistor.

The resistance of the variable resister can be altered which will change the temperature that the circuit will switch on at.

Transistors - Process sub-system

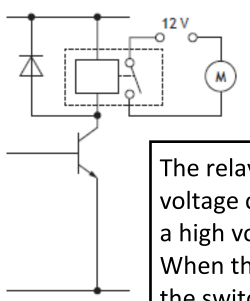
The diode protects the transistor from back EMF (Electro-magnetic Flux). It is a polarity conscious device and can only allow current to flow the way that the arrow points. Connected as shown it will not allow current to flow from the top to the transistor.



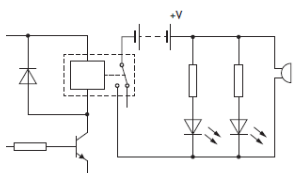
The function of a transistor is to act as an electronic switch. The transistor switches on when the voltage between the base and the emitter (V_{be}) reaches 0.7V. This then allows a current to flow between the collector and the emitter which causes the relay to close the switch.

The base resistor is there to protect the transistor. The voltage across the base resistor will be V_{out} - 0.7V.

Relays & other components - Output sub-system



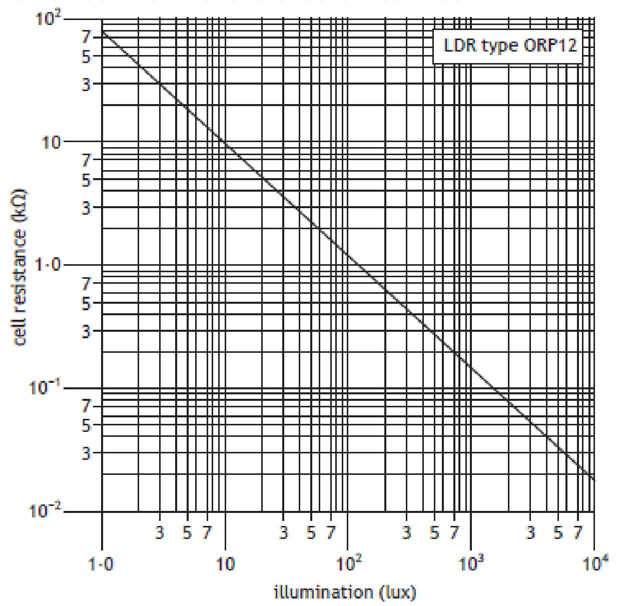
The relay allows a low voltage circuit to control a high voltage circuit. When the relay closes the switch, it completes the circuit causing the motor to spin.



When the relay closes the switch in this circuit, the LEDs light and the buzzer sounds. Various output components can be connected to a relay circuit.

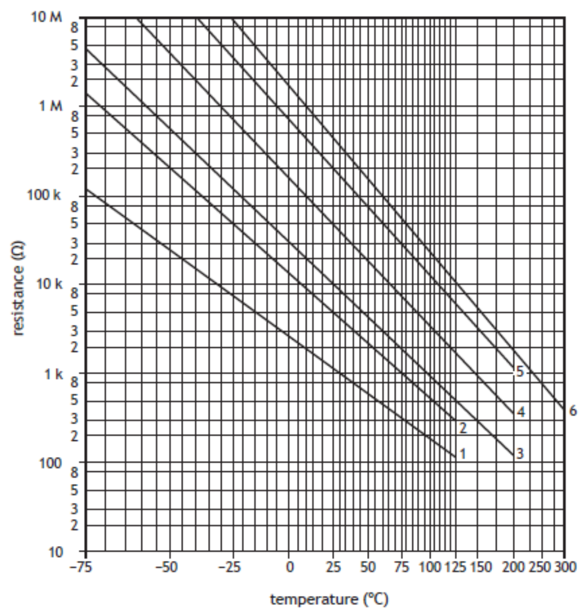
LDR Graph

The LDR graph can be tricky to read. Pay close attention to the values at 1 or 10 to make sure you know whether it's 1s, 10s, 100s or 1000s that you are working with. Remember that the resistance is measured in kΩ.



Thermistor Graph

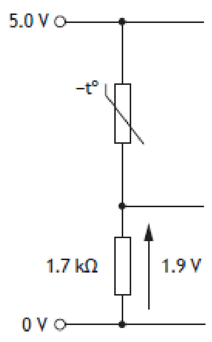
The Thermistor graph also jumps up in large increments on the resistance scale. Be careful to follow the correct thermistor type line to work out your value.



Voltage Divider Calculations

A voltage divider is a series circuit.
Voltages across the two components added together equal the supply voltage.
The current is the same through both components.
To find the total resistance, add the resistances of both components together.

(a) Calculate the resistance of the thermistor.



Step 1 - we know a voltage and a resistance from the bottom part of the circuit so we can calculate current.

$$V = I \times R$$
$$1.9 = I \times 1700$$
$$\frac{1.9}{1700} = I$$
$$I = 1.1mA$$

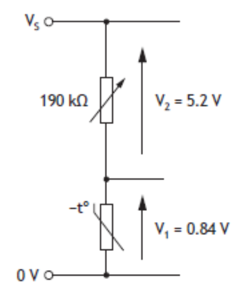
Step 2 - We can now work out the voltage across the thermistor by knowing that the total voltage is the voltage across both components added together.

$$V_S = V_1 + V_2$$
$$5 = V_1 + 1.9$$
$$5 - 1.9 = V_1$$
$$V_1 = 3.1V$$

Step 3 - now we can use Ohm's law again to calculate the resistance of the thermistor using the voltage across the thermistor and the current that stays the same.

$$V = I \times R$$
$$3.1 = (1.1 \times 10^3) \times R$$
$$\frac{3.1}{(1.1 \times 10^3)} = R$$
$$R = 2818\Omega$$

The input sensing circuit (which is part of the warning circuit) is shown below.



(c) Calculate the resistance of the thermistor.

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Step 1 - we know both voltages and one resistance so we can use the formula from the data booklet.

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$
$$\frac{0.84}{5.2} = \frac{R_1}{190}$$
$$0.161 \times 190 = R_1$$
$$R_1 = 31K\Omega$$